Review of: "Technical note: Transit times of reactive tracers under time-variable hydrologic conditions" by Raphael Miazza and Paolo Benettin

This technical note describes how the transit time approach developed for tracking water ages through catchments can be extended to yield transit times of reactive tracers. I find this paper a well written and valuable addition to the theory development around transit time distributions of water and solutes. This study applies the theory of transittime distributions for water to solutes and combines it with assumptions from advective-diffusion solute transport modelling (Retardation: constant equilibrium between dissolved and sorbed concentration, linear decay, fractionation). As such it is a novel contribution. Below I list a couple of suggestions that in my opinion could improve the manuscript:

Overall:

The paper has an unconventional structure: introduction, starting point, New solutions, insights from these new solutions, insights from Numerical implementation of these new solutions, conclusions. Consider a more conventional setup with: Introduction (1), Theoretical development (2, containing the old 2,3&4), Example application(3) methods/setup (3.1), results (3.2), discussion (3.3) and conclusion (6). I can see why you chose your setup: you don't want to put a strong focus on the model implementation and it is not the goal in itself, but now section 5 reads cramped and its goal is unclear.

In the theory development and discussion I miss what your results mean for not fully mixed (i.e preferential flow systems) systems. It looks to me that <u>without</u> the full mixing-assumptions you can almost fully copy the same reasoning and your derivations will also hold for preferential flow systems. Could you not do the theory development for any system and then do your example (section 5) for the fully mixed one? That would make the structure a bit easier to read as well? You can easily write the SoluteMass-Age balance eq:

$$\frac{\partial M(t-s,t)}{\partial t} = M_I(t)\delta(t-s=0) - \frac{M(t-s,t)}{RS(t-s,t)}Q(t-s,t) - \frac{\alpha M(t-s,t)}{RS(t-s,t)}E(t-s,t) - k\,M(t-s,t)$$

Which solves to:

$$p_{Mq}(t-s,t) = \frac{M(t-s,t)}{M(t)} = \frac{M_I(s)}{M(t)}\exp\left(-\int_s^t \left[\frac{Q(t-s,\tau)+\alpha E(t-s,\tau)}{RS(t-s,\tau)} + k\right]d\tau\right)$$

In fact, we can only derive water transit time distributions through following tracers (=solutes) through the system. Thus basically, all previous publications that first derive Pq

$$C_Q(t) = \int_0^\infty C_J(t-T) p_Q(T,t) dT$$

and subsequently use   must have already implicitly applied a Solute transit time distributions, just with R=1, alfa =1 and k = 0 (stable isotopes). I think you can probably show both approaches are exactly the same thing. But you are much deeper into this and can reason better why or why not. I can be convinced that this all can be tackled through extra discussion on mixed systems.

I would suggest to write the conclusions more engaging less bullet-wise

Line 223

"The evapoconcentration parameter α can be seen as a valve that controls the mass directed to ET. When α < 1, less mass will go to ET, resulting in tracer accumulation in storage and thus longer transit times. Conversely, when α > 1 (net tracer extraction) the larger tracer output rate will result in a depleted tracer storage, with faster turnover and shorter transit times." Although entirely correct, I find the valve quite abstract as plats don't have valve but can fractionate at there roots. I would suggest α < 1 for solutes that plants try to keep out of there system (high chloride, toxic solutes), α > 1 for solutes that plants need to for their functioning (Nutrients, trace elements)

Figure 5: Caption it would help add the partition coefficient variables to the caption (I was scanning the paper for θmR, but couldn't find it until close reading the caption)

Conclusion 2 is not clear and to me not really a conclusion: "Such analytical solution builds on the framework initiated by Botter et al. (2010) and extends it to the case of reactive tracers"

#####Unrelated but I had too much fun adding a dissolution term. Maybe for next paper

Just for fun adding a source term that could represent weathering. Not sure if it works :

$$\frac{\partial M(t-s,t)}{\partial t} = M_I(t)\delta(t-s=0) - \frac{M(t-s,t)}{RS(t-s,t)}Q(t-s,t) - \frac{\alpha M(t-s,t)}{RS(t-s,t)}E(t-s,t)$$

$$- k\,M(t-s,t) + \mathrm{j}\left(\frac{M(t-s,t)}{RS(t-s,t)}\text{-C0}\right)$$

$$M(t-s,t) = M_I(s)\exp\left(-\int_{\tau=s}^{t}\left[\frac{Q(t-s,\tau) + \alpha E(t-s,\tau) - j}{RS(t-s,\tau)} + k\right]d\tau\right)$$

$$- jC_0\int_{\xi=s}^{t}\exp\left(-\int_{\tau=\xi}^{t}\left[\frac{Q(t-s,\tau) + \alpha E(t-s,\tau) - j}{RS(t-s,\tau)} + k\right]d\tau\right)d\xi$$